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THE USE OF THE JOINT SIMULTANEOUS INTEGRATION METHODOLOGY TO MEASURE THE IMPACT OF CERTAIN MACROECONOMIC VARIABLES ON THE GDP: ARDL MODEL

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Purpose. The objective of this study is to analyse the evolution of public expenditure, exports, imports, and gross domestic product (GDP) in Algeria over the past four decades (1980–2022). It aims to measure the impact of each of these macroeconomic variables (public expenditure, imports, and exports) on GDP during the study period, in the long and short term. Additionally, the study intends to identify the most significant economic variables influencing GDP in Algeria by constructing an econometric model (autoregressive model) based on economic theory and previous studies. These variables are considered the driving force and effective activator for improving GDP.
Results. The findings obtained using the ARDL bounds testing approach for cointegrated time series revealed the existence of a long-run equilibrium relationship between the independent variables (public expenditure, imports, exports) and the dependent variable (GDP). In the short run, most of the model variables were statistically significant, indicating their influence in explaining GDP. This allows us to conclude that there is a dynamic relationship between the model variables in Algeria during the study period. Additionally, the error correction coefficient was statistically significant at the 5 % level, while the speed of adjustment to equilibrium was 0.8828.
Scientific novelty. Research in this field continues to provide new insights into the dynamic relationship between these important economic factors. While this topic has been explored in previous studies, our research distinguishes itself by examining the collective impact of public expenditure, imports, and exports on GDP. This study establishes a direct link between these variables and GDP. Modern studies emphasise the significance of the composition of public expenditure in determining its impact on GDP. Additionally, several studies have demonstrated the influence of exports and imports on GDP. Imports play a crucial role in enhancing production efficiency and reducing costs within the economy. The current study addresses the gap in previous research by simultaneously examining public expenditure, imports, and exports as independent variables, considering both the pre- and post-Algerian economic reforms period.
Practical value. This study contributes to understanding economic growth trajectories and how various economic components impact GDP. By analysing the influence of public expenditure, exports, and imports on economic growth, the study offers significant added value. It empowers policymakers at the macroeconomic level to leverage these findings in formulating and implementing effective economic policies that can enhance GDP, thereby promoting economic growth and improving living standards through the management of the study variables such as public expenditure,

export values, and imports.

Key words: gross domestic product, public expenditures, imports, exports, ARDL model.

Introduction. Economic growth which is considered a key objective of economic and financial policies, is pursued by most countries. It stands as one of the most important economic indicators that reflects a country's economic situation. This topic has garnered significant attention in economic literature, where numerous theoretical and applied economic models have been studied and analysed. The aim has been to identify the factors that affect economic growth and develop models that explain the nature and direction of the relationship between economic growth and other variables. One of the most widely used measures for economic growth is the GDP index, which serves as a comprehensive indicator of a country's economic performance. It plays a crucial role in preventing the risks of economic backwardness, as it is a global indicator that reflects the level of development in a country's economy. Consequently, countries strive to achieve this goal by implementing a package of macroeconomic policies. (Jacky Mallett & Charles Keen, 2012; Popkova et al., 2018).

Like other rentier countries, Algeria aims to enhance its GDP by navigating the interconnected relationships among economic variables. These relationships stem from the fluctuations in oil and gas prices and involve finding the optimal combination of macroeconomic variables, such as increasing public expenditures, controlling the volume of imports, and promoting exports, in order to boost economic growth rates and achieve integration into the global economy (Eregha & Mesagan, 2020). This objective is a crucial focal point within Algeria's development programs, plans, and economic policy.

Review of literature. While the topic may not be considered modern, there have been limited studies conducted on the variables of interest in Algeria within the framework of the proposed model. For instance, Melikaoui Mouloud (2019) attempted to examine the causal relationship between government spending and GDP in Algeria during the period of 1991–2015. The study explored both Keynesian hypothesis and Wagner's law, and it found a negative impact of government spending on GDP. This finding contradicts economic theory, as it fails to support Keynes's hypothesis. Additionally, the study revealed that the economic classification of expenditures in Algeria did not align with Keynes's hypothesis. Furthermore, the results indicated a negative influence of gross domestic product (GDP) on government spending, indicating a failure of Wagner's law in the Algerian economy. It is worth mentioning that economic data has changed since 2015, and the current study adopts a different methodology. Specifically, it utilizes the simultaneous joint integration approach and focuses on public expenditures, imports, and exports as independent variables. Boularedj & Faouzi (2015), Azzazi & Brakni (2019) conducted studies examining the impact of financial development indicators on GDP in Algeria. In the first study, the focus was on measuring the influence of banking sector development on economic growth in Algeria using indicators such as bank credit divided by gross domestic product (GDP), cash flow to GDP, and highly liquid assets (quasi-money) to GDP. The

study, employing the co-integration method, found no relationship between financial development and economic growth in Algeria. It suggested that improvements in fiscal and monetary indicators were primarily due to other factors, such as high fuel prices. In the study by Azzazi & Brakni (2019), which employed the ARDL approach shared with the current study, a negative relationship between the ratio of private sector credit to real GDP was identified. This suggests a weak impact of the private sector on real GDP. The study also noted that real GDP was moving towards long-term equilibrium at a rate of 113.8 % within a single period (year), indicating that long-term equilibrium would be achieved in less than a year. However, both studies had limited time scopes (1970–2012 and 1990–2017 respectively), and the independent variable differed from the current study. Thus, the current study aims to address the gap left by these studies by considering public expenditures, imports, and exports as independent variables .

Materials and methods. To achieve the study's objectives, a descriptive-analytical approach was employed. This involved analysing the study variables, namely public expenditure, imports, exports, and GDP, during the study period. Modern quantitative techniques based on the Autoregressive Distributed Lag (ARDL) model methodology were utilized to estimate the speed of adjustment to long-run equilibrium. EViews 10, a statistical software package, was employed to model economic phenomena and interpret the theoretical relationships and interactions between the variables.

Results and discussion. *1. Theoretical framework of the study.* GDP is a crucial measure for assessing the economic performance and overall state of a country's economy. It is considered one of the most important indicators because an increase in GDP corresponds to an increase in per capita income, leading to changes in consumption patterns. Conversely, a decrease in GDP can indicate economic instability (Topcu et al., 2020), primary investments are necessary to meet the increasing demands within a country, thus contributing to economic stability (McConnell et al., 1999).

GDP represents the monetary value of all final goods and services produced in an economy during a specified period, usually a year (Powell, 2013; Hoover, 2011; Al-Wazani & Al-Rifai, 2005). It reflects the value of all goods and services produced within a country's geographical boundaries, whether by its nationals or foreigner, (Abel & Gabe, 2011; Bătușaru et al., 2023; Al-Din Al-Eissa, 2001). The calculation of GDP involves considering the market prices of goods and services produced within the country's boundaries, with a focus on the value of final goods and services to avoid double counting (Marcu et al., 2015). The concept of added value is utilized in these calculations (Nahler, 2009).

1.1. An analytical study of the GDP in Algeria during the period (1980–2022). GDP is a comprehensive economic measure that encompasses all economic activities conducted by individuals in Algeria. Over the study period, Algeria actively pursued various reforms to align its economy with emerging global challenges. This new approach had significant implications for the improvement of Algeria's GDP. The Figure 1 below illustrates the progression of GDP in Algeria from 1980 to 2022.

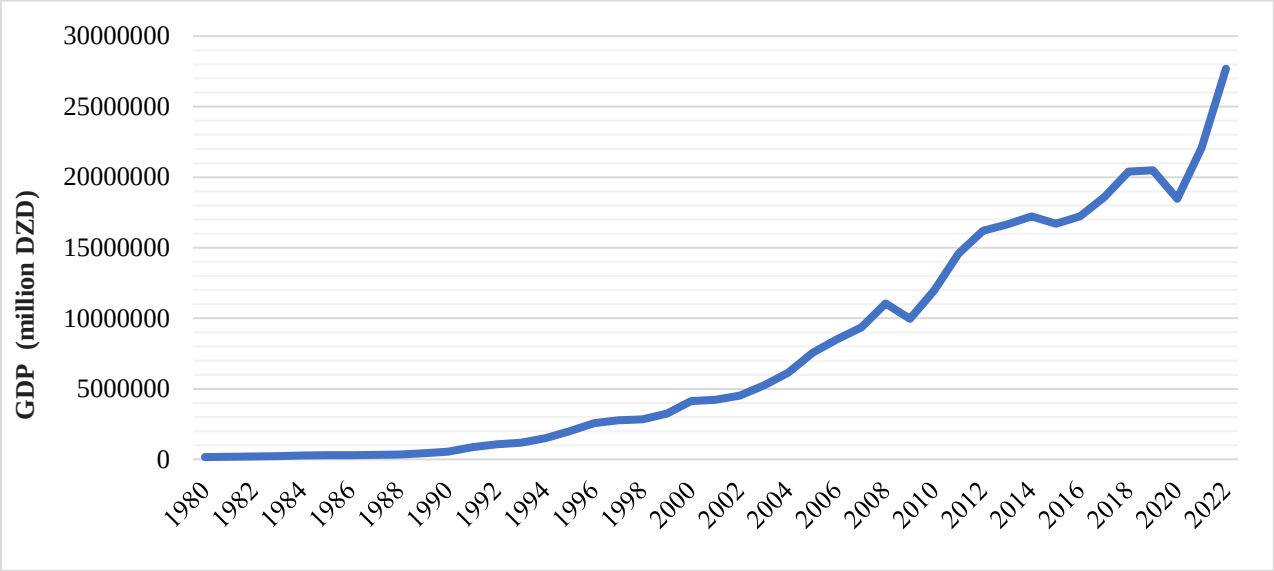

Figure 1. Evolution of the volume of GDP in Algeria during the period (1980–2022)

Source: prepared by the authors based on the reports and publications of the Bank of Algeria (https://www.bank-of-algeria.dz/ar) for the years (1980–2022).

The Figure above reveals significant developments in Algeria's GDP during the period from 1980 to 1985, coinciding with the implementation of the first five-year plan. One of the contributing factors to the growth of Algeria's GDP was the increase in oil prices, which resulted in higher government revenues. However, there was a sharp decline in GDP between 1986 and 1994 due to the oil crisis of 1986. This crisis was characterized by a decline in oil prices and subsequent political and economic changes that impacted Algeria. As a result, Algeria had to seek external financing from financial and international institutions, leading to weak and fluctuating growth in real GDP. During this period, the government was compelled to reduce public spending, which resulted in shortages of essential commodities, high inflation, and increased unemployment (Chemingui & Nassima, 2003; Safia & Selma, 2019).

Between 2000 and 2022, Algeria experienced a period of rapid and continuous GDP growth. During this time, GDP increased from 4,123.51 billion dinars in 2000 to 11,090 billion dinars in 2008, with an average annual growth rate of 20.8 % (Central Banks of Algeria, 2011). This growth was primarily driven by higher oil and gas prices, which reached a peak of 98.6 USD per barrel in 2008. The increase in prices resulted in higher government revenues and increased public expenditures (Aldawood et al., 2022). It also led to an improvement in the balance of payments and a reduction in the trade balance deficit to 133.2 billion dinars, equivalent to 1.1 % of GDP (Central Banks of Algeria, 2011). During this period, the Algerian government invested the increased revenues in various economic sectors, following the Economic Recovery Strategy (2001–2004) and the Supplementary Program to Support Economic Growth (2005–2009). These measures contributed to the growth of GDP (Central Banks of Algeria, 2007). However, the global financial crisis in 2008 and the subsequent sharp decline in oil and gas prices had a negative impact on government revenues. As a result, the

Algerian government had to implement austerity measures, leading to a decrease in GDP. However, the economy quickly recovered, and GDP reached 17,228.59 billion dinars in 2014, driven by high oil and gas prices, which are crucial for the Algerian economy (Central Banks of Algeria, 2017). Additionally, favorable climatic conditions contributed to the recovery of the agricultural sector (Bouchareb & Morad, 2023), from 2015 to 2022, GDP fluctuated due to successive declines in oil prices and the impact of the Covid-19 pandemic crisis (Madani et al., 2020).

1.2. Analytical study of public expenditures in Algeria during the period (1980–2022). One of the primary objectives of economic development plans is to achieve increased economic growth. This objective can be accomplished through an increase in public spending, which is considered one of the key tools of fiscal policy. This view is supported by Keynesian theory, as Keynes observed the fundamental relationship between public spending and the growth of national income following the Great Depression of 1929. He highlighted the multiplier effect, which demonstrates how investment spending impacts the overall increase in national income (Ertekin & Bulut, 2021). It is generally assumed that the causation in this relationship flows from public spending to GDP, meaning that economic growth rises as the volume of public spending increases (Al-Alusi & Al-Satouri, 2023). Keynes advocated for state intervention in economic activity by increasing spending on public projects to stimulate economic activity during periods of recession (Seccareccia, 2011). This approach contributed to the emergence of a new economic role for the state (Deubel et al., 2008).

In the context of the Algerian economy, there has been notable development in the allocation of public expenditures during the study period. The evolution of government expenditures is illustrated in Figure 2.

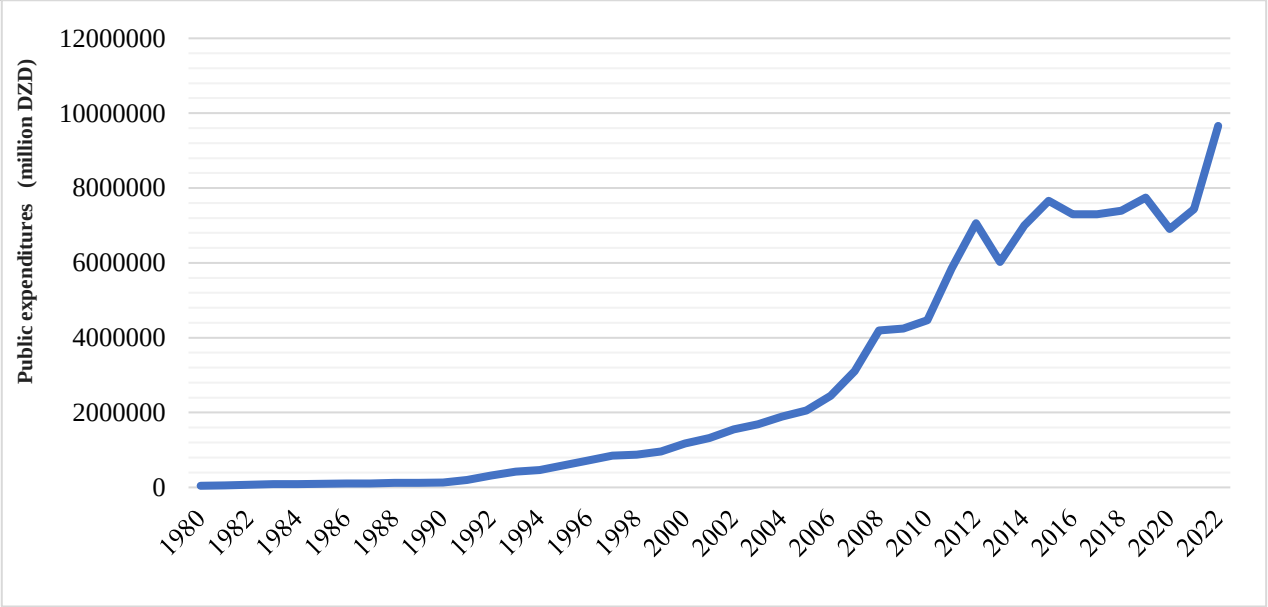

Figure 2. Evolution of the volume of public expenditures in Algeria during the period (1980–2022)

Source: prepared by the authors based on the reports and publications of the Bank of Algeria (https://www.bank-of-algeria.dz/ar) for the years (1980–2022).

The Figure above indicates that public expenditures in Algeria experienced

modest growth rates during the period from 1980 to 2000. This period coincided with the oil shock of 1986, the devaluation of the dollar, and Algeria's implementation of structural reforms supported by the International Monetary Fund. These reforms aimed at reducing government spending and diversifying forms of state support (Akacem, 2004; Boulafi & Yemani, 2013). Public expenditures increased from 44.016 billion dinars in 1980 to 1,178.122 billion dinars in 2000, representing an increase of over 26 times. From 2001 to 2014, public expenditures in Algeria grew at a rapid pace, primarily driven by the improvement in fuel revenues. Oil prices reached 98.6 USD per barrel in 2008, 111.3 USD per barrel in 2011 (Aldawood et al., 2022) and USD 96.29 per barrel in 2014 (OPEC, 2024). This explains the significant increase in expenditures from 1,321.028 billion dinars in 2001 to 6,995.769 billion dinars in 2014 (Central Bank of Algeria, 2016). These years witnessed the implementation of various economic recovery programs, such as the Economic Recovery Program (2001–2004), the Economic Growth Support Program (2005–2009), and the Economic Growth Consolidation Program (2010–2014), which required substantial financial resources, However, from 2015 to 2022, public expenditures fluctuated due to the successive decline in global oil prices since mid–2014. The Algerian government implemented a series of austerity measures, as reflected in the finance law of that year (Abdelkader & Mohammed, 2017; Boulila & Benbouziane, 2018). Expenditures experienced both increases and decreases, with the lowest value recorded in 2020 at 6,902.9 billion dinars (Central Bank of Algeria, 2023). It is notable that oil prices and public expenditures are closely correlated in most years, indicating the impact of oil revenues on government spending in Algeria.

1.3. An analytical study of imports in Algeria during the period (1980–2022). Imports play a significant role in a country's GDP as they contribute to long-term economic development and support the productive apparatus. While imports can impose a burden on GDP, they are also crucial for developing exports, improving living standards, and creating conditions for growth. Imports fulfil the needs of the local market by providing goods and services that are not available domestically. They also contribute to raising the level of local investment and enhancing the productive capacities of economic sectors through technology transfer and the import of machinery and equipment. On the Figure 3 illustrate the evolution of imports in Algeria from 1980 to 2022.

The above Figure clearly indicates a period of stability in import earnings from 1980 to 2001, with amounts ranging between USD 10.552 billion in 1980 and USD 9.940 billion in 2001. This stability can be attributed to the decline in export earnings (Wang et al., 2022), which primarily rely on oil revenues. Oil prices in the global markets were low during this period, as oil serves as the main source of hard currency (Shaqbaqab & Ben Ziane, 2017). After 2001, there was a notable increase in the volume of imports. It reached USD 39.479 billion in 2008 and continued to rise further during the period of 2009–2014, with the highest volume recorded at USD 59.670 billion in 2014 (Central Bank of Algeria, 2016).

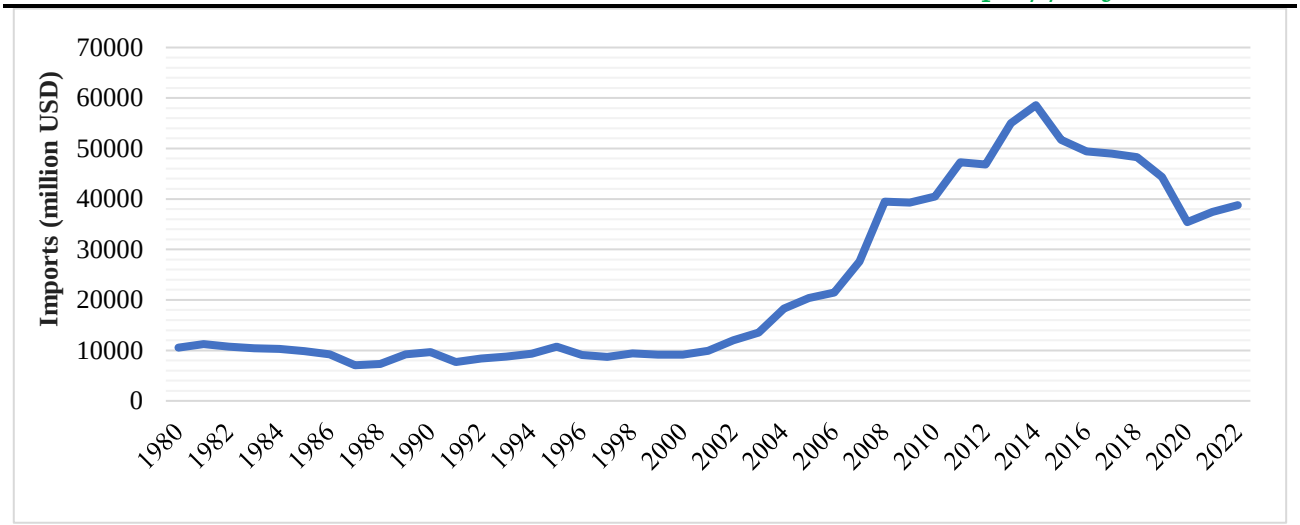

Figure 3. Evolution of the volume of imports in Algeria during the period (1980-2022)

Source: prepared by the authors based on the reports and publications of the Bank of Algeria (https://www.bank-of-algeria.dz/ar) for the years (1980–2022).

This increase can be attributed to the following reasons:

– Significant expansion of the import of processing materials with a view to ending the public investment programmes adopted in 2001;

– The global food crisis and the marked rise in the prices of basic commodities, especially wheat;

– Overall demand for durable goods has increased significantly due to higher wage salaries;

– Population increased, resulting in increased demand for all kinds of goods.

During the recent period of 2015–2022, following the global crisis of 2014, there was a noticeable decline in the volume of imports. This decline was primarily attributed to a decrease in the volume of hydrocarbon exports by 8.8 %, which was a result of the decline in average petroleum prices. Consequently, the decline in oil revenues led to a reduction in the coverage of imports through exports, decreasing from 65 % in 2015 to 55.5 % in 2016 (ONS, 2017). To address this situation, the Algerian government implemented a series of measures aimed at controlling and rationalizing imports. Some of these measures include:

– Review the value of the Algerian dinar against the main currency adopted by the Central Bank;

– roofing of many imports through the establishment of an import licensing system;

– Oblige all car dealerships to invest locally.

1.4. An analytical study of exports in Algeria during the period (1980–2022). Exports serve as a means of releasing surplus production to foreign economies, providing hard currency, generating added value, and yielding revenues. They also contribute to increasing the volume of GDP, thus fostering economic development and improving economic growth rates. According to the multiplier theory, an initial

increase in exports leads to a greater overall increase in GDP due to multiplier effects. The Figure below shows the evolution of the volume of exports in Algeria during the period (1980–2022).

The above Figure reveals significant fluctuations in Algeria's exports, primarily driven by changes in oil prices. In the mid-1980s, the decline in oil prices resulted in a decrease in export volume, reaching its lowest point at USD 7.82 billion in 1986. Consequently, the Algerian government was compelled to reduce public spending and increase taxes. During this period, the Algerian government implemented a series of economic reforms and pursued diversification of exports, including agricultural and industrial products. However, non-oil exports still remained a small percentage of the total.

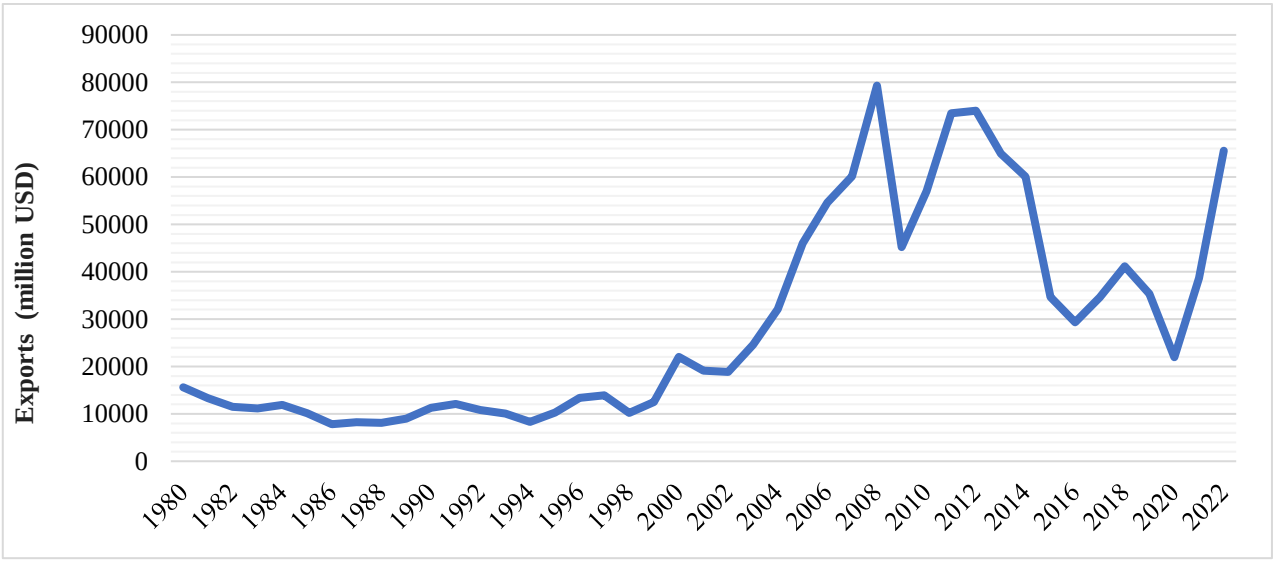

Figure 4. Evolution of the volume of exports in Algeria during the period (1980–2022)

Source: prepared by the authors based on the reports and publications of the Bank of Algeria (https://www.bank-of-algeria.dz/ar) for the years (1980–2022).

Furthermore, the Figure demonstrates a consistent increase in export volume from 2000 to 2008. It rose from USD 22,031 million in 2000 to USD 79,298 million in 2008, representing a growth rate of 259.93 %. This growth was primarily driven by the rise in oil prices, which reached USD 94.45 per barrel in 2008. However, the global crisis in 2009 and the subsequent decline in global oil demand caused a decline in export volume. This downturn was a consequence of Algeria's heavy reliance on oil. Subsequently, exports experienced growth from 2010 to 2014, reaching USD 57,053 million and USD 60,054 million, respectively (Central Bank of Algeria, 2016). This growth coincided with the recovery of oil prices and impacted all types of exports. However, exports declined again after 2014 (Central Bank of Algeria, 2019), primarily due to low oil prices. The hydrocarbon sector, constituting over 97 % of total exports, is heavily influenced by fuel prices in international markets and the amount of oil production sold. The lowest export value was recorded in 2020 at USD 21,935 million (Central Bank of Algeria, 2022), attributed to the impact of the Covid-19 pandemic, which resulted in reduced international exchanges, disrupted transactions, and

paralysed commercial transport. However, Algeria's exports have shown signs of recovery and achieved their highest value since 2014, reaching USD 65,526 million in 2022 (Central Bank of Algeria, 2022). This recovery is the outcome of Algeria's efforts in implementing development plans and strategies aimed at diversifying and enhancing exports.

2. Econometric study. After conducting a thorough theoretical study, the next step is to construct an econometric model to examine the relationship between GDP and several variables that have been identified as having an impact during the period of 1980–2022 in Algeria. The variables of interest in this model are public expenditures, exports, and imports. By analysing these variables, the aim is to determine the factors that significantly influence GDP in Algeria.

2.1. Data source. Annual data from 1980 to 2022 were collected from a single source, specifically the reports and publications of the Algerian Bank over several years. The Eviews10 program was utilized to process this data and estimate the study model. Through the use of Eviews10, the data underwent analysis and econometric calculations, enabling us to generate meaningful results for our study.

2.2. Model description. Based on economic theory and prior studies that postulate a relationship between the dependent variable (GDP) and the independent variables (public expenditures, exports, imports), a model representing this relationship can be specified as follows:

$$pib_t = \beta_0 + \beta_1 \times dep_t + \beta_2 \times impo_t + \beta_3 \times expo_t + \varepsilon_t \,, \qquad (1)$$

where pib_t – denotes gross domestic product;

dep_t – represents public expenditures;

$impo_t$ – represents imports;

$expo_t$ – represents exports;

β_0 – represents the constant term;

$\beta_1,\ \beta_2,\ \beta_3$ – are the coefficients associated with the respective independent variables;

ε_t – represents the random error term.

This econometric model formulation allows for the estimation of the coefficients ($\beta_1,\ \beta_2,\ \beta_3$) and the assessment of the statistical significance and magnitude of the impact of public expenditures, imports, and exports on GDP in the context of the Algerian economy during the period under consideration.

2.3. Econometric methodology. The impact of public expenditures, imports, and exports on GDP will be measured using the Autoregressive Distributed Lag (ARDL) model. This model is particularly suitable when the variables exhibit a combination of stationarity at levels I(0) and first differences I(1). The ARDL methodology allows for the determination of the complementary relationship between the dependent variable and the independent variables in both the short and long run (Pesaran et al., 2001).

Furthermore, this approach facilitates the quantification of the magnitude of the effect that each independent variable has on the dependent variable. For instance, when considering variables X and Y, and aiming to measure the impact of variable X on

variable Y, the equation can be expressed as:

$$\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 X_{t-1} + \sum_{i=1}^{m} \beta_i \Delta Y_{t-i} + \sum_{i=0}^{n} \gamma_i \Delta X_{t-i} + \varepsilon_t . \quad (2)$$

In the initial stage of estimating the ARDL model, a bounds test is conducted to determine the presence of a long-run cointegrating relationship among the core variables, irrespective of their order of integration being 0 or 1. The ARDL model estimation involves two steps: firstly, examining the existence of a long-run equilibrium relationship between the variable levels, and secondly, if such a relationship is confirmed, estimating the long-run equilibrium parameters and the short-run dynamic error correction model parameters.

To examine the relationship between macroeconomic variables and GDP in Algeria, the researcher will assess the stationarity and cointegration properties of the study variables: Gross Domestic Product (GDP), Public Expenditure (DEP), Imports (IMPO), and Exports (EXPO).

Detecting and addressing outliers (extreme values). Among the potential issues that arise when dealing with time series data is the presence of outliers, which may need to be addressed if deemed necessary. Outliers in the data series can be detected by constructing a box-plot representation using the Eviews10 software. The box-plot is a useful graphical tool for visualizing the distribution of a dataset and identifying potential outliers. It displays the median, interquartile range (IQR), and any data points that lie outside the range of 1.5 times the IQR from the lower and upper quartiles. These data points that fall outside this range are considered potential outliers and may warrant further investigation or treatment.

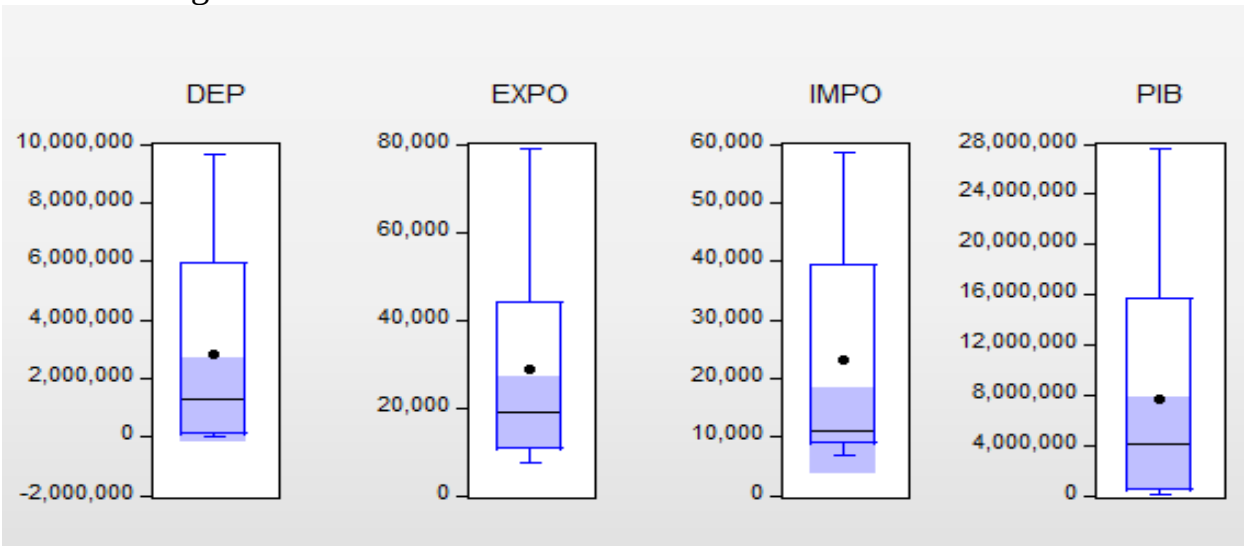

Figure 5. Study of the series of outliers

Source: developed by the authors based on the outputs of the Eviews10 program.

The illustration above distinctly reveals that every string is devoid of any outliers, presenting a dataset characterized by uniformity and absence of extreme values.

2.4. Stationarity analysis. In this subsection, we will conduct a stationarity test using the Dickey-Fuller test, which encompasses three distinct models. Below are the resultant outcomes derived from this analysis.

Table 1

Dickie fuller test results

UNIT ROOT TEST TABLE (ADF)					
At Level					
	Variables	PIB	DEP	EXPO	IMPO
With Constant	t-Statistic	3.2769	4.3173	-1.1571	-2.7378
	Prob.	*1.0000*	*1.0000*	*0.6839*	*0.0774*
	Significant	n0	n0	n0	*
With Constant & Trend	t-Statistic	-0.8957	0.4462	-2.2861	-3.8249
	Prob.	*0.9466*	*0.9986*	*0.4319*	*0.0262*
	Significant	n0	n0	n0	**
Without Constant & Trend	t-Statistic	4.6025	4.8295	-0.1044	0.6688
	Prob.	*1.0000*	*1.0000*	*0.6419*	*0.8566*
	Significant	n0	n0	n0	n0
At First Difference					
		d(PIB)	d(DEP)	d(EXPO)	d(IMPO)
With Constant	t-Statistic	-4.1370	-1.3057	-5.6015	-4.7863
	Prob.	*0.0024*	*0.6147*	*0.0000*	*0.0004*
	Significant	***	n0	***	***
With Constant & Trend	t-Statistic	-6.1695	-6.3838	-5.5428	-4.0058
	Prob.	*0.0000*	*0.0000*	*0.0002*	*0.0183*
	Significant	***	***	***	**
Without Constant & Trend	t-Statistic	-0.4536	-0.1851	-5.5980	-4.7081
	Prob.	*0.5118*	*0.6117*	*0.0000*	*0.0000*
	Significant	n0	n0	***	***

Note. ***, **, * refer to levels of significance at 1 %, 5 % and 10 %, respectively; (n0) – not significant.

Source: developed by the authors based on the outputs of the Eviews10 program.

The results of the developer Dicky Fuller's test show us the following:

- The GDP series, PIB, exhibits non-stationarity at the level form, as the probability of error exceeds 5 % across all models. As a result, the null hypothesis, H_0, suggesting the presence of a unit root, is accepted. Consequently, it is necessary to take the first difference of the series. Upon examining the differenced variable, it becomes evident that the probability of error is below 5 % in both models: the one incorporating a constant and a trend, and the one with only a constant. This indicates that the series has achieved stationarity, and the GDP series is integrated of order one, denoted as I(1);

- The public expenditure series, DEP, exhibits non-stationarity at the level form, as the probability of error exceeds 5 % across all models. Consequently, the null hypothesis, H0, suggesting the presence of a unit root, is accepted. However, after taking the first difference, the series achieves stationarity. This is observed in the model that incorporates a constant and a trend. Therefore, the public expenditure series is integrated of order one, indicated as I(1);

- The export series, EXPO, demonstrates non-stationarity at the level form, as the probability of error surpasses 5 % across all models. Consequently, the null hypothesis,

H_0, signifying the presence of a unit root, is accepted. Therefore, it is necessary to take the first difference of the series. Upon examining the differenced variable, it is observed that the probability of error is below 5 % in all models, indicating its significance. As a result, the export series achieves stationarity at the first difference, denoted as I(1);

- The import series, IMPO, is found to be stationary at the level form, as the probability of error is below 5 % in the model that includes a constant and a trend. This model demonstrates statistical significance, leading us to reject the null hypothesis and accept the alternative hypothesis (the series does not contain a unit root). Therefore, the import series is integrated of order zero I(0).

Since the series exhibit a combination of I(0) and I(1) components, the most suitable model for studying the relationship is the Autoregressive Distributed Lag (ARDL) model.

2.5. Co-integration test using the bound-test method. The bounds test is employed to test for the presence of a long-run cointegrating relationship among the variables under study. This test is based on the Fisher distribution. If the calculated F-statistic exceeds the upper bound critical value, it indicates the presence of a long-run equilibrium relationship between the study variables. However, if the calculated value falls below the lower bound critical value, the null hypothesis is accepted, implying the absence of a long-run equilibrium relationship. The obtained results are as follows:

Table 2

Testing the boundary approach of the model

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif., %	I(0)	I(1)
Asymptotic: n=1000				
F-statistic	8.955958	10.0	2.37	3.20
K	3	5.0	2.79	3.67
		2.5	3.15	4.08
		1.0	3.65	4.66
Actual Sample Size	39	Finite Sample: n=40		
		10.0	2.592	3.454
		5.0	3.100	4.088
		1.0	4.310	5.544
		Finite Sample: n=35		
		10.0	2.618	3.532
		5.0	3.164	4.194
		1.0	4.428	5.816

Source: developed by the authors based on the outputs of the Eviews10 program.

From the Table 2, it can be observed that the calculated F-Bounds statistic value is 8.95, which exceeds the upper bound critical value of 3.67 at the 5 % significance level. As a result, the null hypothesis, which suggests the absence of a long-run relationship, is rejected, while the alternative hypothesis (H_1), indicating the presence of a long-run equilibrium relationship between the independent variables and the dependent variable under study, is accepted. This outcome confirms the existence of a

cointegrating relationship among the variables and establishes a long-run equilibrium relationship from public expenditures, imports, and exports to GDP.

2.6. Estimation of long-term equilibrium relationship. After confirming the existence of a long-run equilibrium relationship, the next step in the ARDL methodology involves estimating the long-run parameters. In the first stage, the lag lengths are determined using the Akaike Information Criterion (AIC), as depicted in the following Figure displaying the selected lag lengths based on the minimum criterion adopted.

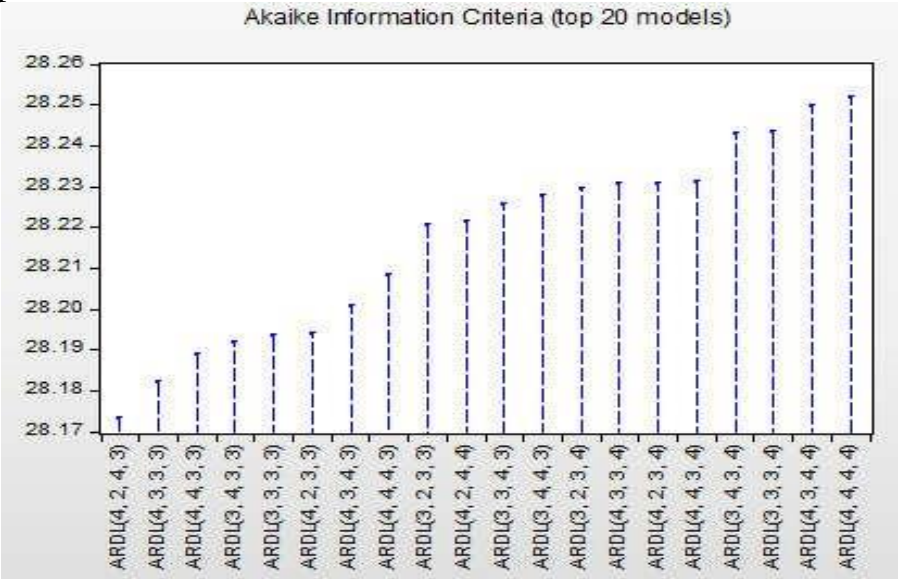

Figure 6. Lag lengths of the ARDL model

Source: developed by the authors based on the outputs of the Eviews10 program.

It is evident from the figure that the optimal lag lengths obtained according to the Akaike criterion are as follows: 4 for PIB, 2 for DEP, 4 for EXPO, and 3 for IMPO (hence, the optimal model order is: ARDL (4, 2, 4, 3). With the optimal lag lengths determined, the next step involves estimating the long-run coefficients of the ARDL model, capturing the long-run equilibrium relationship among the variables under study.

2.7. Long-term relationship. The long-term parameters of this model are estimated, as shown in the following Table 3.

Table 3

Results of estimating the long-term parameters of the model

Levels Equation				
Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
DEP	3.336916	0.166423	20.05082	0.0000
EXPO	31.37982	21.00657	1.493810	0.1494
IMPO	-135.8457	36.17836	-3.75488	0.0011
C	1129032.0	195346.7	5.779631	0.0000
EC = PIB - (3.3369*DEP + 31.3798*EXPO -135.8457*IMPO + 1129032.0462)				

Source: developed by the authors based on the outputs of the Eviews10 program.

2.8. Estimation of the short-term relationship and the ECM error correction

model. After estimating the long-term relationship, the researcher estimates the short-term relationship with the error correction coefficient, where the results were as follows:

Table 4

Estimation of the error correction model and the short-term relationship of the model

ARDL Error Correction Regression				
Dependent Variable: D(PIB)				
Selected Model: ARDL(4, 2, 4, 3)				
Case 2: Restricted Constant and No Trend				
Date: 03/26/24 Time: 05:03				
Sample: 1980–2022				
Included observations: 39				
ECM Regression				
Case 2: Restricted Constant and No Trend				
Variable	Coefficient	Std. Error	t-Statistic	Prob
D(PIB(-1))	0.202505	0.100598	2.013015	0.0565
D(PIB(-2))	-1.033184	0.151399	-6.824261	0.0000
D(PIB(-3))	0.606149	0.219642	2.759714	0.0114
D(DEP)	1.210780	0.190711	6.348763	0.0000
D(DEP(-1))	-1.487252	0.255325	-5.824925	0.0000
D(EXPO)	69.13130	7.488411	9.231771	0.0000
D(EXPO(-1))	35.82160	10.86426	3.297196	0.0033
D(EXPO(-2))	72.72128	10.49973	6.926014	0.0000
D(EXPO(-3))	-31.39386	16.51315	-1.901143	0.0705
D(IMPO)	-35.99855	22.40333	-1.606839	0.1223
D(IMPO(-1))	11.29700	21.03795	0.536982	0.5967
D(IMPO(-2))	95.33826	21.04260	4.530727	0.0002
CointEq(-1)*	-0.882846	0.121358	-7.274721	0.0000
R-squared	0.972536	Mean dependent var.		703975.6
Adjusted R-squared	0.959860	S.D. dependent var.		1254442
S.E. of regression	251328.0	Akaike info criterion		27.96811
Sum squared resid.	1.64E+12	Schwarz criterion		28.52263
Log likelihood	-532.3781	Hannan-Quinn criter.		28.16706
Durbin-Watson stat.	2.147140	-		-

Source: developed by the authors based on the outputs of the Eviews10 program.

The empirical results from the Autoregressive Distributed Lag (ARDL) model estimation deserve particular attention. It is noteworthy that the majority of the explanatory variables exhibit statistical significance, indicating their relevance in explaining the variations in the dependent variable. Additionally, the error correction coefficient is negative and statistically significant (-0.882846), suggesting the presence of a correction mechanism that adjusts deviations from the long-run equilibrium at a speed of approximately 88.28 % per period. This implies that the equilibrium position is reached within a period of approximately one year and two months. Furthermore, the results confirm the existence of a short-run dynamic relationship between the independent variables and the dependent variable.

The empirical findings also reveal that the adjusted coefficient of determination (R-squared) is 0.9598, implying that approximately 95.98 % of the variations in GDP can be attributed to changes in the explanatory variables included in the short-run dynamic model. The remaining 4.02 % can be attributed to other factors not explicitly incorporated into the model specification. Furthermore, these results underscore the importance of the included macroeconomic variables, namely public expenditures, imports, and exports, in explaining the variations in GDP in the Algerian economy over the studied period. The model's ability to capture both short-run dynamics and long-run equilibrium relationships enhances its reliability and applicability for policy analysis and forecasting purposes.

2.9. Diagnostic Tests. To ensure the reliability and validity of the estimated model and its adherence to the underlying assumptions, a series of diagnostic tests were conducted, as follows:

2.9.1. Serial Correlation Test. For this purpose, the Breusch-Godfrey Lagrange Multiplier (LM) test was employed, which tests the following two hypotheses:

H_0: No serial correlation of errors between residuals;

H_1: Serial correlation exists between residuals.

The null hypothesis is accepted or rejected based on the probability value associated with the test statistic. If the probability value (p-value) is greater than the chosen significance level (typically 5 %), the null hypothesis of no serial correlation is accepted. Conversely, if the p-value is less than the significance level, the null hypothesis is rejected, indicating the presence of serial correlation in the residuals.

The LM test is widely used in econometric analysis to detect the presence of autocorrelation, which is a violation of the assumption of independence among residuals. Failure to address serial correlation can lead to inefficient parameter estimates and invalid statistical inferences.

Table 5

Breusch-Godfrey Serial Correlation LM Test Results

F-statistic	0.874982	Prob. F(4,18)	0.4981
Obs*R-squared	6.348731	Prob. Chi-Square(4)	0.1746

Source: developed by the authors based on the outputs of the Eviews10 program.

Based on the results of the Breusch-Godfrey Lagrange Multiplier (LM) test for serial correlation, it is observed that the probability (p-value) of the test statistic is 0.4981, which is greater than the conventional significance level of 0.05. Therefore, there is insufficient evidence to reject the null hypothesis of no serial correlation among the residuals. Consequently, the null hypothesis, which indicates the absence of autocorrelation among the residuals, is accepted.

This outcome suggests that the estimated model does not suffer from the problem of serial correlation, which is a desirable property, as the presence of autocorrelation can lead to inefficient parameter estimates and invalid statistical inferences. By accepting the null hypothesis of no serial correlation, we can proceed with the assumption that the residuals are independently distributed, which is a crucial assumption in econometric modeling.

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2.9.2. Test for Autoregressive Conditional Heteroskedasticity (ARCH). To investigate the stability of the error variance, the Autoregressive Conditional Heteroskedasticity (ARCH) test is commonly employed. This test examines the presence of heteroskedasticity, a condition where the variance of the residuals is not constant over time. The results of the ARCH test were as follows (Table 6).

Table 6

Heteroskedasticity test: ARCH

F-statistic	1.207396	Prob. F(4,30)	0.3282
Obs*R-squared	4.853214	Prob. Chi-Square(4)	0.3027

Source: developed by the authors based on the outputs of the Eviews10 program.

Based on the ARCH test results, it can be observed that the probability value (p-value) of the F-statistic is 0.3282, which exceeds the conventional significance level of 0.05. As a result, the null hypothesis of homoskedasticity, which indicates that the variance of the errors is constant (homogeneous), is accepted.

2.9.3. Test for Normality of Residuals [Jarque-Bera (JB)]. The Figure below presents the results of the Jarque-Bera (JB) test, which is used to assess whether the residuals of the estimated model follow a normal distribution or not. The Jarque-Bera test statistic measures the difference between the skewness and kurtosis of the residuals from those of a normal distribution. The null hypothesis of this test states that the residuals are normally distributed.

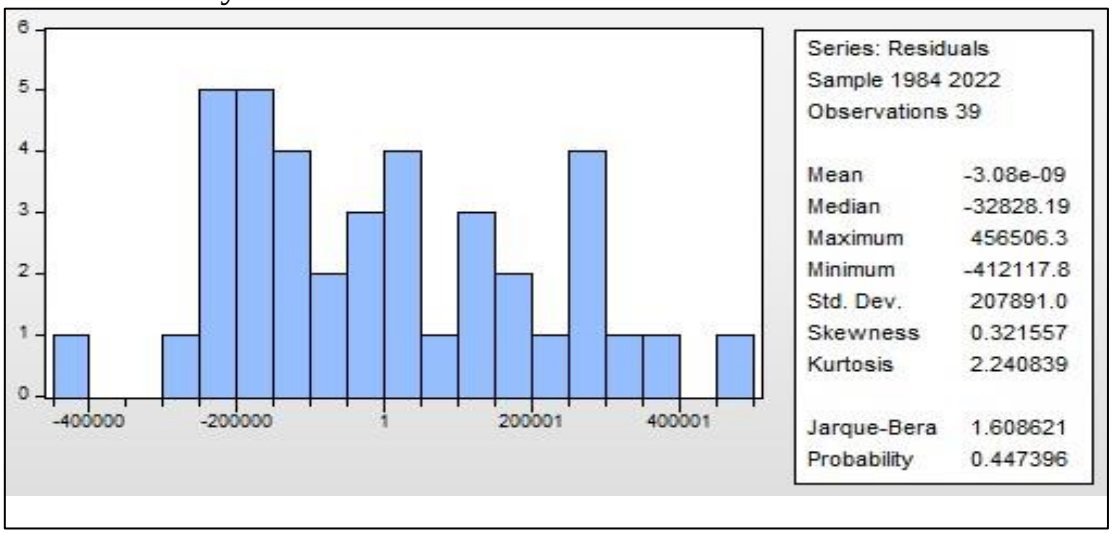

Figure 7. Test for normal random error distribution [Jarque-Bera (JB)]

Source: developed by the authors based on the outputs of the Eviews10 program.

It can be observed from the Figure 7 that the probability value (p-value) associated with the Jarque-Bera test statistic is 0.4473, which is greater than the conventional significance level of 0.05. This result leads to the acceptance of the null hypothesis, confirming that the random errors (residuals) follow a normal distribution at the 5 % significance level.

2.10. Model Stability. To ensure the validity and robustness of the estimated model, it is crucial to evaluate its structural stability and ensure that it is free from potential structural changes or breaks. In this regard, the researcher employed two widely recognized tests: the Cumulative Sum of Residuals (CUSUM) test and the

Cumulative Sum of Squares of Residuals (CUSUMSQ) test. These tests are particularly significant in assessing the stability and consistency of the long-run parameters with the short-run dynamics. Numerous empirical studies have incorporated these tests in conjunction with the Autoregressive Distributed Lag (ARDL) methodology.

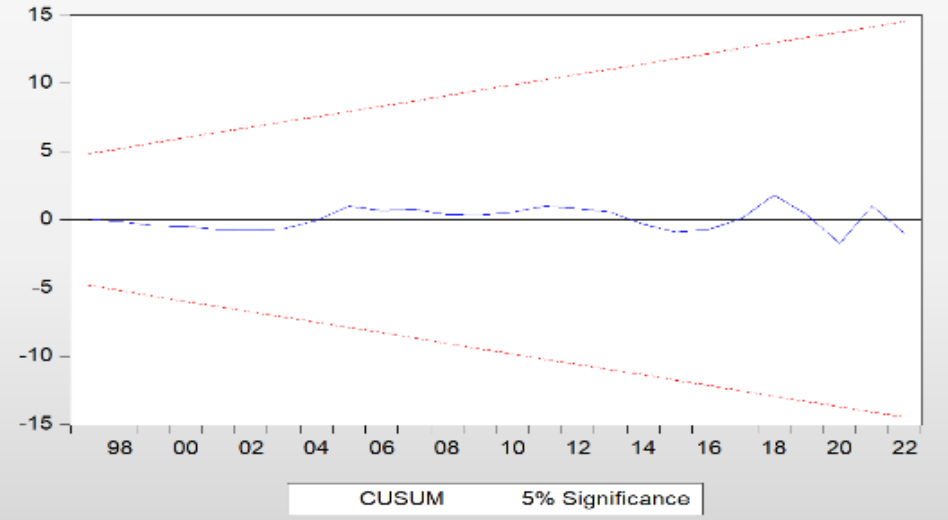

Figure 8. Cumulative sum of follow-up residues

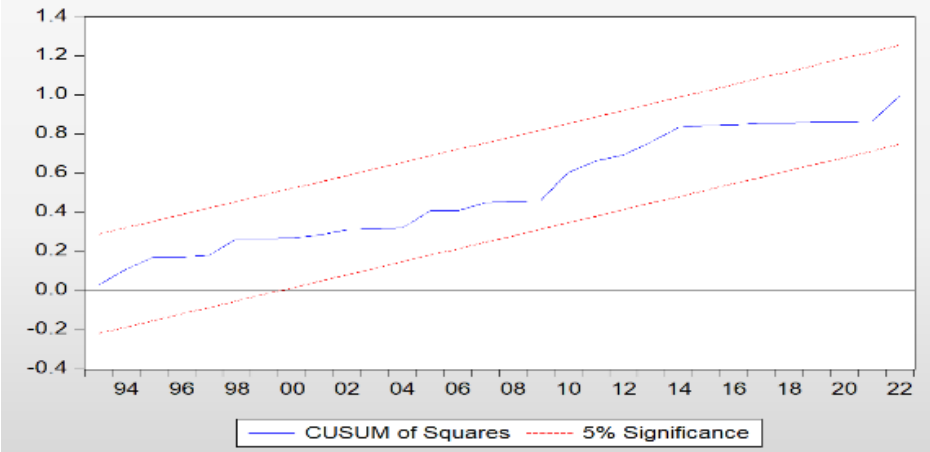

Figure 9. Cumulative sum of squares of follow-up residues

Source: developed by the authors based on the outputs of the Eviews10 program.

Based on the graphical representations provided in Figures (8) and (9), it can be observed that the plots of the CUSUM and CUSUMSQ statistics remain within the respective critical bounds at the 5 % significance level over the specified sample period. Specifically:

– Figure 8 – CUSUM Test: The cumulative sum of recursive residuals falls within the two critical lines, indicating that the coefficients of the model are stable over time;

– Figure 9 – CUSUMSQ Test: The cumulative sum of squares of recursive residuals also remains within the critical bounds, further confirming the stability of the estimated coefficients.

These results from the CUSUM and CUSUMSQ tests indicate that the model is

structurally stable at the 5 % significance level over the study period.

Discussion. The findings derived from the conventional study can be comprehensively analysed as follows:

1. GDP, public expenditures, and exports demonstrate integration of order 1 (I(1)), while imports exhibit integration of order 0 (I(0)). This indicates a first-order interdependence among these variables, thus enabling the utilization of the Autoregressive Distributed Lag (ARDL) model.

2. Upon estimation of the long-term relationship, it is observed that public expenditures (dep) exhibit statistical significance at the 5 % significance level (prob = 0.00<0.05). A positive correlation between public expenditures and GDP is identified, in accordance with economic theory. Specifically, a one million dinars increase in public expenditures is associated with an expected GDP rise of 3.3369 million dinars. These outcomes substantiate the hypothesis that state public expenditure plays a pivotal role in driving economic growth by bolstering the productive capacity of the national economy. This finding aligns with Keynesian economic theory, which asserts that public spending stimulates economic growth through the Keynesian multiplier effect.

3. Conversely, exports (expo) do not demonstrate statistical significance at the 5 % level (prob = 0.1494>0.05). Nonetheless, a positive relationship between exports and GDP is observed, consistent with economic theory.

4. Imports (impo) are determined to be statistically significant at the 5 % significance level (prob = 0.0011<0.05). An inverse relationship between imports and GDP is identified, in line with economic theory. Specifically, a one million dollar increase in imports is associated with an expected GDP decrease of 135.8457 million dinars. These results validate that an elevation in global oil prices leads to augmented oil revenues, subsequently resulting in heightened import volumes and a decline in GDP.

5. The fixed limit C is statistically significant and positive, indicating that other economic variables considered in the model exert a positive influence on GDP.

6. Estimation of the error correction model and the short-term relationship demonstrates statistical significance for most variables. The significant parameters in the model table suggest the existence of a dynamic short-term relationship among the variables.

7. The error correction coefficient indicates the pace at which variables revert to the equilibrium state. It must be both significant and negative to signify the presence of cointegration among the variables. The absolute value of the error correction coefficient denotes the rate of restoring the equilibrium state, with a negative sign indicating short-term model convergence. The negative and significant coefficient associated with the error correction term serves as a more effective indicator of cointegration. In this model, the error correction coefficient (1-) is negative and approximately 88.28 %, with a statistically significant probability (prob = 0.00<0.05). This suggests that GDP requires around one year and two months to return to its normal

equilibrium state following a shock in the model induced by a change in one of the variables included in the model (1/0.8828).

Conclusions. This study aimed to examine the impact of public expenditures, imports, and exports on GDP using the Autoregressive Distributed Lag methodology. The cointegration test proposed by Pesaran, which is valid for variables integrated at different orders between zero and one and performs well with small sample sizes, was employed. The key findings of the empirical analysis are as follows:

1. A cointegrating relationship exists between GDP and the variables included in the model, as evidenced by the F-statistic value exceeding the upper bound critical value in the bounds test. The negative and statistically significant error correction coefficient signals the presence of a long-run equilibrium relationship. These results confirm the necessary and sufficient conditions for a long-run relationship among the variables. Short-run deviations can be corrected, and long-run equilibrium can be restored within approximately one year and two months, allowing for the adjustment of short-run imbalances and a return to equilibrium. Thus, the hypothesis of the study is validated.

2. While a positive relationship between exports and GDP was observed, it did not reach statistical significance at the 5 % level.

3. The model demonstrates an overall explanatory power exceeding 90 %, which is considered good for interpretation and analysis.

4. The model is free from standard econometric problems, such as serial correlation, heteroskedasticity, and non-normality of residuals.

5. Algeria's GDP is influenced by public expenditures, imports, and exports in both the long and short run.

Based on these findings, the following recommendations can be made:

1. Improve the business environment by streamlining administrative procedures and providing incentives for investors, aiming to attract foreign direct investment and leverage expertise and technology to reduce production costs in non-oil sectors such as industry, agriculture, and tourism.

2. Enhance the efficiency and control of public expenditure management, decoupling spending from oil revenues that are subject to fluctuations in oil exports, in order to achieve economic stability.

3. Prioritize the diversification of exports away from the hydrocarbon sector and promote it as a strategic option for achieving sustainable development, ensuring a more stable and prosperous future for Algeria.

4. Sustain the macroeconomic reforms initiated, independent of the country's financial situation. Develop plans to improve the investment climate and remove obstacles to facilitate capital movements.

5. Establish stable laws that positively impact the investment climate and encourage private sector participation in economic activities.

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